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USE AND CONSERVATION OF NATURAL GAS

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UNITED STATES FUEL ADMINISTRATION

BUREAU OF OIL CONSERVATION

The 2,000,000 housekeepers in the United States who use natural gas could save at least $36,000,000 worth of gas annually if their cooking appliances were properly adjusted

UNIVERSITY OF CALIFORNIA AT LOS ANGELES
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WHAT A SAVING OF 1,000 CUBIC FEET OF NATURAL GAS PER MONTH BY EACH DOMESTIC CONSUMER IN THE UNITED STATES WILL ACCOMPLISH TO HELP WIN THE WAR.

Save 2,300,000,000 cubic feet of gas per month.

This would release coal sufficient to make 2,000,000 3-inch shells—about the same as the famous French "75's"—per month.

Would release enough coal to send one 15,000-ton troopship overseas every day. The troopship can not burn gas, but must have coal, which, on account of the coal shortage, takes coal away from the plant making shells. Gas is used in shell and other munitions manufacture, and the gas that the domestic consumer can save will release that equivalent amount of coal.

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HOW WE GET NATURAL GAS.

The first step in obtaining natural gas is securing a lease or right to drill a well. This lease must usually be paid for for several years prior to beginning actual drilling, on the optimistic but unproven faith that there may be gas under it. On an average for the entire United States every fourth hole is dry or gasless. When the well is drilled, in order to protect it and prevent the earth from caving in, an iron pipe (called a casing) is driven down through the hole and into rock which is always found above gas-bearing sand. If gas is found, a plugging device, known as a "packer," is fastened in the casing or hole in the rock just above the gas sand; and the gas, because of its natural expansive tendency, then comes to the earth's surface, usually one-half mile above, through a pipe called "tubing," which is screwed into the packer. This tubing is then connected by underground pipe to the consumer's fixtures, generally many miles away, as shown on pages 8 and 9. Thus the natural gas used in Toledo, Ohio, is transmitted 294 miles; at Noblesville, Ind., 341 miles; Marion, Ind., 322 miles; Columbus, Ohio, 174 miles; Louisville, Ky., 205 miles; and Kansas City, Mo., 237 miles.

The gas is never at rest, but is a constantly seething, moving mass, traveling in the mains at enormous velocities—at a speed many times exceeding that of the fastest trains—and requires constant attention from the well until it is burned at the consumer's fixtures.

When the gas is removed from the gas sand the natural pressure (called rock pressure) must decline. As the gas travels through the pipes the friction causes the pressure to drop. These two features require the installation of expensive compressors for raising the gas pressure so as to compel it to travel to the ultimate consumer. The compressor is a mechanical device to squeeze the gas into a smaller volume, the object being to expedite transmission, just as cotton, hay, or straw are compressed for shipment.

The broad public interest in an effective and continuous service and a future generation's equity in a future supply makes it the duty of the gas-producing company—

First. To conserve the supply of gas in every way possible. By conservation is meant not merely saving but using in the most effective manner. This means that it is the duty of the gas company to remove every foot of gas from the ground that can be economically obtained.

Second. Every appliance known to gas mining should be used to bring about the most economical production of the gas and most effective method of transmission and distribution. Since a normal characteristic of every gas field is that its natural pressure declines as the gas is removed, it becomes necessary to increase the rapidly declining pressure by mechanical means.

GAS SAND.

In no case is the gas found in rooms, caverns, or large crevices, as popularly supposed. The gas sands are simply very porous rocks which contain millions upon millions of small or microscopic cavities, so that the gas occupies these numerous spaces and thus saturates the rock. The gas is obtained by puncturing this sand rock by the hole which is drilled from the earth's surface.

WRONG IMPRESSION OF WORD "NATURAL."

While natural gas is a product made by nature, it is no more natural than other materials, like coal, oil, or iron ore. The word "natural" came into common usage probably as contrasted with manufactured gas, and the use of the word appears to have given a fallacious impression that natural gas was a free and unlimited natural resource. Merely being made by nature does not mean that a substance is cheap and of low value. Natural gas is a natural resource which men have learned to use for the satisfaction of their wants. The misconception regarding the position of natural gas has arisen from failing to appreciate that man creates no new matter, and can merely get the materials of nature ready for consumption, since every product of industry owes its origin to natural resources.

GEOGRAPHICAL DISTRIBUTION.

Natural gas is found in 23 States, but 98 per cent of the total production is in West Virginia, Pennsylvania, Oklahoma, Ohio, Louisiana, Kansas, California, Texas, and New York. Forty per cent of the total production comes from West Virginia.

MAGNITUDE OF NATURAL-GAS INDUSTRY IN THE UNITED STATES.

There are over 2,300,000 domestic natural-gas consumers.

Of all the towns in the United States that have gas, about one-half use natural gas.

About 800 billion cubic feet of gas were produced last year.

This represents about 75 per cent of all gas sold in the United States—that is, the manufactured gas sold is only about one-fourth of the total.

NATURAL GAS IS BECOMING SCARCER.

The demands for natural gas are now greater than the available supply. Food and trees can be grown. Water supplies are constantly replenished by nature, but there is no regeneration in natural gas; and when the gas is once used it is gone forever. While no one knows exactly how natural gas is formed, yet enough facts are known about it to indicate that nature's process was a very slow one. It has taken millions of years to make the present concentrated sup-

plies, and even though gas should now be formed in some parts of the earth's crust, the rate of formation will be so slow as to make such new gas pools of no interest or economic value for centuries.

The use of natural gas is not an inalienable right, but a privilege enjoyed by about 10 per cent of our entire population in the United States, used in a most extravagant and wasteful manner, with no regard for the future and not appreciated until it is gone.

EXTENT OF WASTE.

The history of the natural-gas industry is an appalling record of almost unbelievable waste. The common methods of production, transmission, and use have resulted in wasting more gas than has ever been utilized. At the present time a survey of the entire natural-gas industry indicates clearly that the amount of waste even to-day is greater than the amount of gas actually utilized. At the present time we are wasting over 800 billion cubic feet of gas per annum. On the basis of what it would now cost to replace this ideal fuel, the money value of this waste amounts to $1,200,000,000 a year, or more than $3,000,000 per day.

There are many distributing plants that waste one-third of the gas by various forms of leakage in the town; that is, they deliver to the ultimate consumers not to exceed two-thirds of the gas received at the town limits. Some of the consumer's wastes are enumerated on page 7.

WHAT IT WILL COST TO REPLACE NATURAL GAS.

Natural gas is purer and has about twice the heating value of any manufactured gas that could be made. Man with all his skill has never been able to manufacture gas that is equal in quality to the natural gas which is now so generally wasted.

To replace the 800 billion cubic feet of gas now annually used would cost about $1,200,000,000 annually.

In tests made in the Department of Home Economics of the Ohio State University to determine the relative costs of various fuels for cooking the following startling relationships were found:

Natural gas at $1.12 per M. is equivalent to coal at $6.50 per ton.
Natural gas at $2 per M. is equivalent to gasoline at 27 cents per gallon.
Natural gas at $2.20 per M. is equivalent to electricity at 3 cents per kilowatt.
Natural gas at $2.40 per M. is equivalent to coal oil at 15 cents per gallon.

USES OF NATURAL GAS.

At the present time one-third of all the natural gas produced is used for domestic service and two-thirds is used for industrial work.

VARIATION IN DOMESTIC NATURAL-GAS CONSUMPTION.

The following shows the monthly variation of a typical domestic consumer:

	M.		M.
July	1	January	23
August	2	February	30
September	4	March	10
October	6	April	5
November	7	May	2
December	14	June	1

The domestic load variation is such that although the entire plant capacity is necessary for the peak demands during the wintertime, the average domestic load is only about one-third of the maximum.

WHY INDUSTRIAL GAS HAS BEEN SOLD.

In the preceding section it was shown that the average load on a natural-gas plant was only about one-third of the total capacity necessary to meet the winter demand. This emphasizes the many opportunities for rendering service which the domestic consumer can not utilize. In order to sell gas cheaper to the domestic consumer and use the plant for a larger number of hours, the companies began selling gas to industrial users during the summer months, when the domestic consumption was very low. Since in most fields there is unrestricted competition between various companies, this had the immediate effect to make it impossible for any one company to conserve the gas for future use without cooperation with its competitors. The public has frowned upon any arrangements for cooperation on the theory that competition was desirable. This has resulted in a wild race between the various companies, each trying to get the gas out of the field, with the result that the supplies were drained very heavily and are, therefore, not available for further use.

CONSUMER IS RESPONSIBLE FOR PROPER USE OF GAS.

The great importance of the proper position of cooking vessels is discussed elsewhere in this pamphlet. Even with high pressure and long flames, if a strong draft should deflect the flame the cooking service will be unsatisfactory. Better results can be obtained with pressures in the neighborhood of 1 ounce than at 4 ounces or higher, if the vessel is properly placed over the shorter flames resulting from the lower pressure. A burner with a large number of short flames will give better results than with long flames. This is such an important feature that practically twice as much gas will be required to cook with 4 ounces of pressure as would be required for pressures of from 1 to 2 ounces.

When mantle burners are opened so as to admit more gas than is necessary the familiar "hissing" or blowing sound is produced. This has, first, a tendency to break the mantle and chimney; second, waste the gas; and, third, lower the candlepower of the lamp. The majority of natural-gas consumers do not appreciate that gas burners need care and attention, and that periodic cleaning is absolutely essential if satisfactory results are to be obtained.

On account of the low gas prices that have prevailed, gas-appliance manufacturers have not been stimulated to the development of efficient gas-using equipment. There have been few improvements resulting in increased efficiency in the last 15 years. In testing house-heating furnaces it has been found that—

(*a*) The use of natural gas in the fire pot of a coal furnace utilizes only about 25 per cent of the heat energy in the gas and wastes 75 per cent.

(*b*) The use of natural gas in the ordinary gas furnace utilizes about 35 per cent of the heat energy in the gas and wastes 65 per cent.

(*c*) The use of natural gas in a correctly designed and built gas furnace where the construction conditions permit the fullest utilization of the heat in the gas will utilize about 75 per cent of the heat energy in the gas, wasting about 25 per cent. There are a number of furnaces on the market especially constructed for the fullest utilization of natural gas.

In tests made by the Bureau of Standards it was found that the ordinary incandescent mantle lamp, where used with natural gas, wasted nearly half of the possible heat that could be used if such lamps were designed for as efficient operation on the high-heating value of natural gas as they give on the low-heating value of manufactured gas.

HOW THE CONSUMER CAN SAVE GAS.

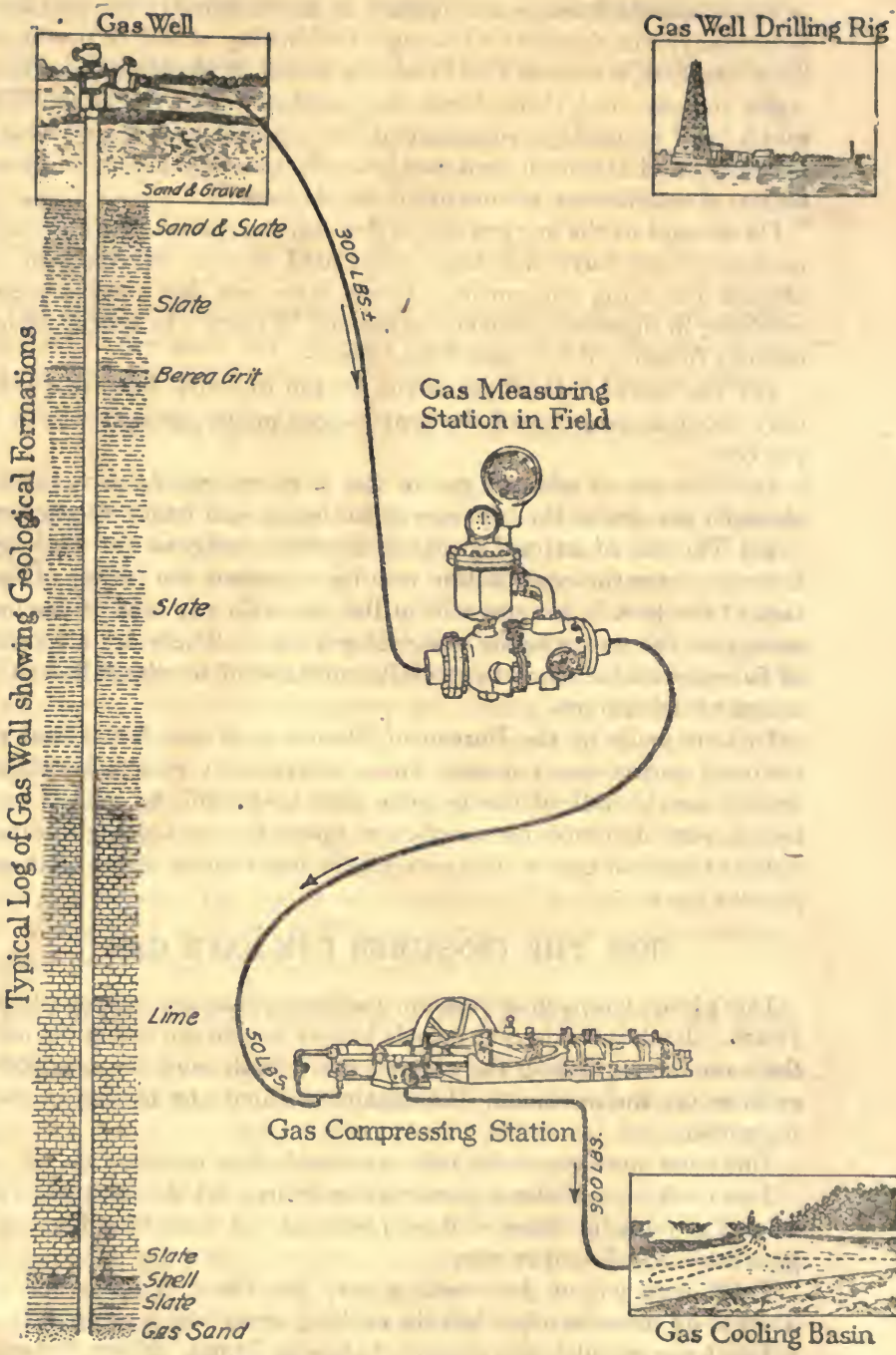
Don't burn lamps in daytime or use lamps that are improperly adjusted. Each incandescent mantle burner has an adjusting device at the base for regulating the air and gas. Both must be so adjusted as to secure the maximum illumination without any hissing or roaring sound.

Don't use more gas under hot-water tank than is necessary.

Don't burn gas without proper air mixture. If the mixture is not correct a wasteful flame will be produced. A pale blue flame will give the most efficient results.

Don't turn gas on for cooking until the vessel is ready for use. Turn it off immediately when the cooking operation is completed.

Don't use gas at high pressure with long flames. Short flames, if properly directed, consume less gas for the same cooking operation.



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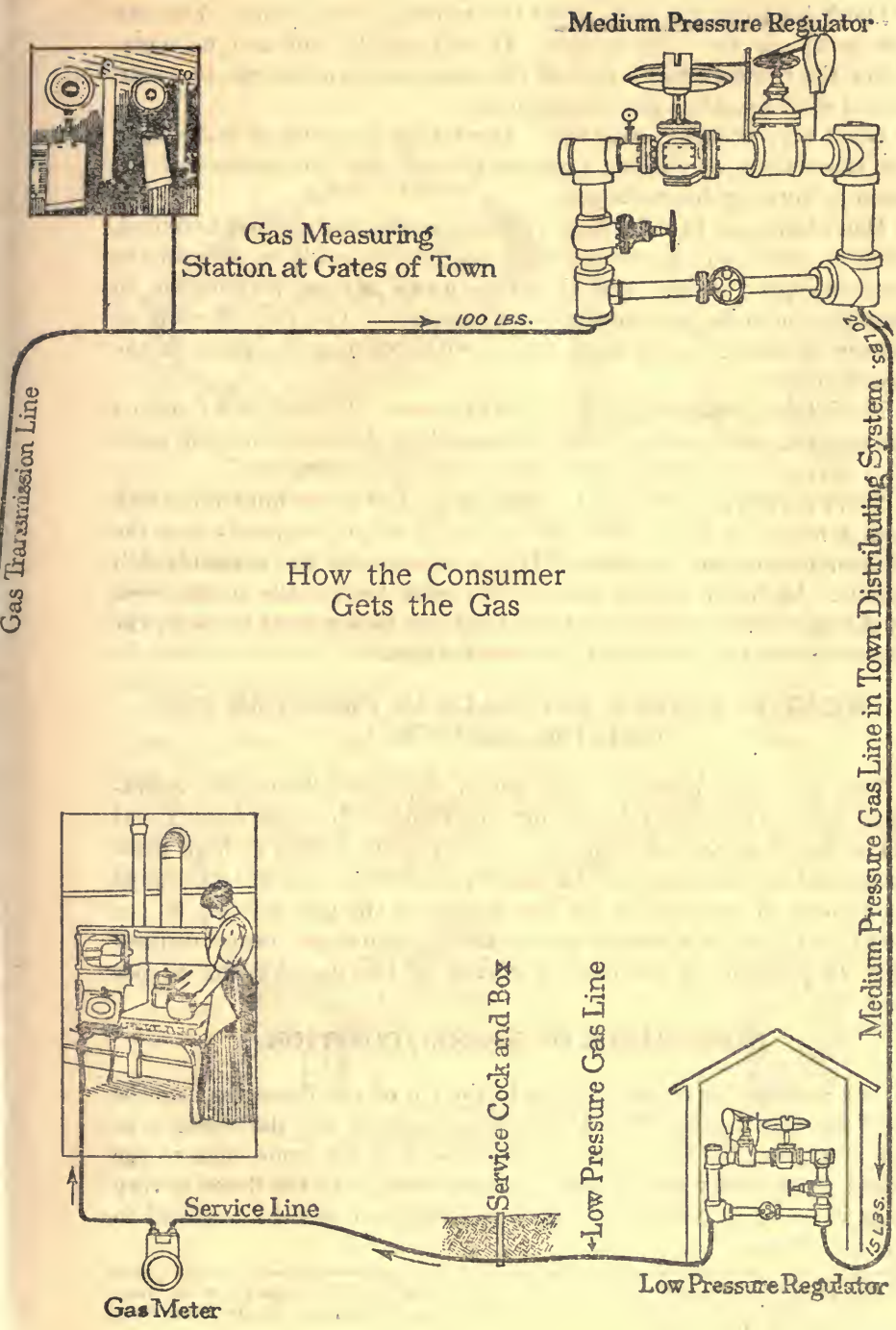
Medium Pressure Regulator
Gas Measuring
Station at Gates of Town
100 LBS.
Gas Transmission Line
How the Consumer
Gets the Gas
Medium Pressure Gas Line in Town Distributing System
Service Cock and Box
Low Pressure Gas Line
Service Line
Gas Meter
Low Pressure Regulator

Don't turn the gas high after the cooking vessel boils. You can not make the food any hotter. It will simply boil and no more. After the contents begin to boil the same temperature can be maintained with a smaller gas consumption.

Don't keep rooms at over 68°. Don't keep windows or doors open for other than ventilating purposes; lower the temperature of the room by turning down the gas.

Don't burn gas in a furnace without automatic thermostat control. Such an automatic device is always on the job, ready to prevent the overheating of rooms, and therefore waste of gas, in addition to keeping the room at a uniform temperature. The cost of such an automatic device is not large and it will soon pay for itself in the saving of gas.

Don't burn gas in an ordinary coal furnace. It is wasteful and its use requires much more gas for the same heat delivered into the room than is required with specially built natural-gas furnaces.

Don't permit gas leaks on the premises. But *never* hunt for a leak with a match or light. The easiest way is to put soapsuds over the pipe or connection suspected. If gas is escaping the soapsuds will bubble. In many houses where tests have been made it has been found that about one-sixth of the total gas that passed through the meter was wasted by leaking pipe and fixtures.

WHAT IS USABLE NATURAL-GAS PRESSURE FOR COOKING SERVICE?[1]

This was determined in tests which duplicated household operations rather than fancy laboratory conditions. In these tests it was found that less gas was required at low pressures than at high pressures, and at two-tenths of an ounce pressure the natural-gas range used about 37 per cent of the heat energy of the gas, wasting 63 per cent; and that at 4 ounces pressure the natural-gas range utilized only 13 per cent of the heating energy of the gas, wasting 87 per cent.

IMPORTANCE OF VESSEL POSITION.

For cooking operations it is only the tip of the flame that can be used for effective service. If the flame is short and the vessel is so far away that the hot point of the flame does not come close to the vessel, satisfactory results can not be obtained. If the flame is very long in order to reach the high vessel the stove will be wasteful in the use of gas.

[1] The data on the following pages are from tests made in the Department of Home Economics, Ohio State University, Columbus, Ohio, and published in the Ohio State Bulletin, No. 28, May, 1918.

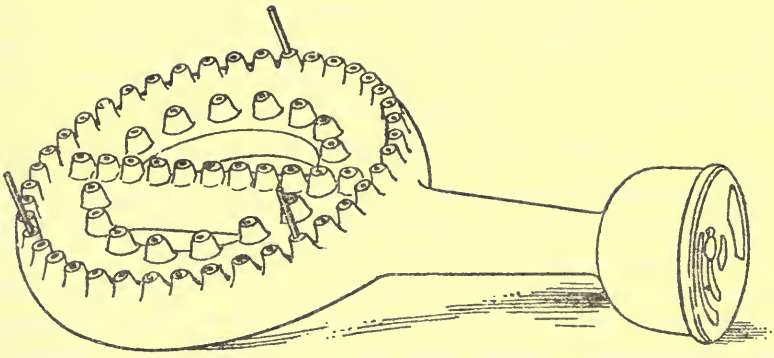

FIG. 1.—Drilled burner with nail or wire inserts to support cooking vessel for low pressure natural gas service.

In order to bring the vessel to the best operating position for short flames all that is necessary is some device that will hold the vessel the correct distance from the burner. With the drilled type of burner this can be easily accomplished by removing the stove top and inserting three nails or pieces of wire, as shown in figure 1, and then placing the vessel on the top of these. With the slotted type of burner, remove the stove top and simply insert three pieces of sheet iron or heavy tin, as shown in figure 2, and then place the vessel on the top of these. This is the only change necessary in order to secure satisfactory cooking results with the ordinary stove with low pressures and the resulting short-flame lengths.

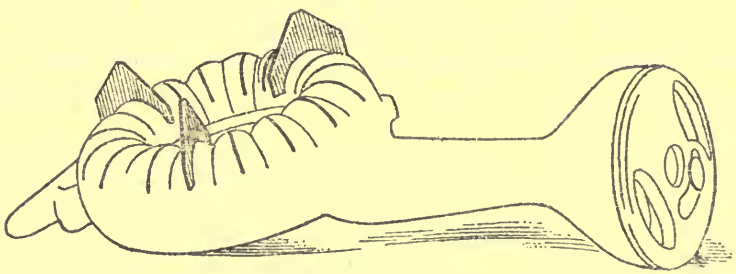

FIG. 2.—Slotted burner with three pieces of sheet iron for supporting cooking vessel for low pressure natural gas service.

ACCURACY OF METER REGISTRATION AT LOW AND VARIOUS GAS PRESSURES.

The popular belief is that meters run faster when the pressure is low than when the pressure is high. This is contrary to the facts. Variation in pressure makes no appreciable difference in the registration of the meter, the meter merely registering, within a reasonable limit of tolerance, the amount of gas that passes, and this is neither increased nor decreased by changes in pressure.

COMBUSTION OF NATURAL GAS.

The combustible constituents of natural gas are made up of combinations of the elements carbon and hydrogen. When natural gas is burned so as to secure perfect combustion only carbon dioxide and water vapor are formed; that is, the carbon of the gas unites with the oxygen of the air, forming carbon dioxide, and the hydrogen of the gas unites with the oxygen of the air, forming water vapor. The water vapor, of course, will condense when cooled. This water vapor does not come from the gas, but is created and formed by the chemical action of the hydrogen in the gas and the oxygen in the air.

Each cubic foot of natural gas burned requires approximately 9½ cubic feet of air, forming 10½ cubic feet of combustion products, which are made up of 2 cubic feet of steam, 1 cubic foot of carbon dioxide, and 7½ cubic feet of nitrogen, all thoroughly diffused through each other.

The combustion of 1,000 cubic feet of natural gas will form 2,000 cubic feet of water vapor or steam, and this when condensed will make approximately 10½ gallons of water. This is not peculiar to natural gas, but is true of all gases containing hydrocarbon compounds. One thousand cubic feet of manufactured gas will form about one-half the water vapor produced by the combustion of 1,000 cubic feet of natural gas. It is this water vapor that causes the bakers and broilers of stoves to rust, and where gas is used in open fires without flues, or for lighting, makes the walls and windows sweat and glued furniture open up.

If the combustion is not perfect, then carbon monoxide, which is a deadly poison, may be formed. The toxic action of this is so marked that one-tenth of 1 per cent is enough to produce fatal results. This is especially likely to be formed when a flame is suddenly impinged on a cold surface, as for instance, the first few seconds' operation of an instantaneous hot-water heater.

ACTION OF GAS MIXER.

As stated in the preceding section, about 9½ cubic feet of air must be mixed with each cubic foot of natural gas in order to secure perfect combustion. In order to accomplish this the gas at a pressure above atmospheric air is forced through a small orifice by the gauge

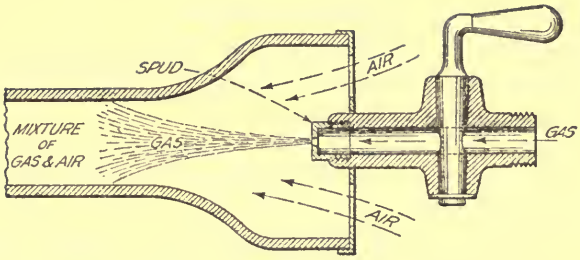

FIG. 3.—Showing construction of ordinary gas mixer.

pressure in the gas pipe, and thus acquires a relatively high velocity in passing through the small opening, as shown in figures 3 and 4. In this way an aspirating action is produced around the orifice and this draws atmospheric air from the room in so that it will mingle with the gas. A gas mixer is, therefore, in effect merely a small air injector. The mixer shown in figure 3 is the one most generally used, and has no adjustment for the gas. The mixer shown in figure 4 has a stationary cone and by turning the spud, with a wrench on the hexagonal head of the spud, the effective area of the orifice may be made larger or smaller, thus changing the velocity of the gas, and, therefore, its aspirating action.

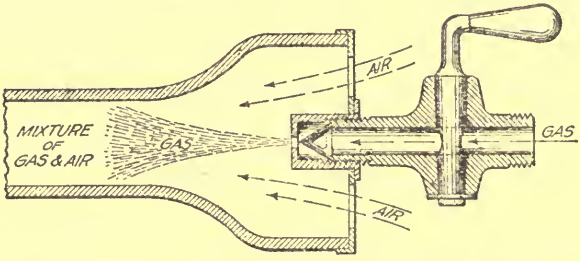

FIG. 4.—Showing construction of gas mixer with adjustable spud.

COOKING AND HEATING DISTINGUISHED.

In a heating operation it is merely necessary to secure perfect combustion in the heating device, because in so doing all of the available heat in the gas can be utilized. In cooking it is not only desirable to secure perfect combustion, but absolutely necessary to direct the heat to a particular place and sometimes at a particular time. It is for this reason that gas-cooking operations are more susceptible to changed pressure conditions than heating operations.

It may not be amiss to emphasizs that the time element in many cooking operatians is of much more importance than intensity.

CONCLUSIONS.

1. Satisfactory cooking operations in frying potatoes, boiling potatoes, frying beefsteak, and pan-broiling beefsteak can be carried on with 0.2 ounce natural gas pressure.

2. The changes in vessel position necessary to permit satisfactory operation at pressures as low as 0.2 ounce are easy to make and require no special changes in existing stoves.

2. Bread can be satisfactorily baked with 0.5 ounce natural gas pressure.

4. Natural gas stoves are not properly constructed to use natural gas efficiently at high pressures nor satisfactorily at low pressures.

5. At high pressure natural gas stoves are inefficient and therefore wasteful in their use of gas.

6. The burners on natural gas stoves are too low.

7. The holes in the spuds of natural gas stoves are too small.

8. Long flames for cooking operations are wasteful.

9. The maximum results are obtained with many short flames rather than a few long flames.

10. A strong draft of air may deflect the flame away from cooking vessel so as to seriously interfere with and in many cases stop cooking.

11. Where two flames strike each other, due to the fact that openings are too close in burner, poor combustion will result. This will produce a luminous flame, which will in turn result in a smoking burner. Neither air nor gas adjustment can overcome this.

12. Drilled burners are better than slotted burners, because there is less likelihood of two adjacent flames striking against each other, therefore producing imperfect combustion conditions.

13. Natural gas cook stoves should not be furnished with solid stove tops, since this suggests the carrying on of cooking operations on top of the stove rather than with the vessel in the proper position.

14. At low pressures no perceptible change can be made in the combustion conditions by adjusting the air shutter. The best conditions obtained were with the shutter wide open.

15. Too much heat is used in most cooking operations. Correct application is more important than mere intensity.

16. The natural-gas pressures carried in most natural-gas distributing plants are too high for efficient operation.

17. Meter registration is approximately correct regardless as to variation in pressure. That is, meters do not run faster when the pressure is low.

18. Lowering the temperature of natural gas increases its heating value per cubic foot. Natural gas has a temperature about 25° lower in the coldest month in winter than in the hottest month in summer, and the heating value per cubic foot due to change in temperature is therefore about 5 per cent higher in the coldest month in winter than in the warmest month in summer.

19. The maximum possible variation of heating value due to variation in gauge pressure would make the heating value during the low-pressure periods in winter less than 3 per cent lower than during the high-pressure period in summer.

20. Since the heating value increase due to low temperature of gas in winter more than offsets the possible decrease in heating value due to low pressure the practical effect of the two is that the heating value per cubic foot of natural gas as served in the winter under low pressures and low temperature is higher than that served in the summer under higher pressures and higher temperature.

21. Variation in barometer from day to day may make more of a change in the heating value of gas than any possible variation in gauge pressure.

22. Better and more efficient service could be rendered if natural-gas pressures were generally lowered to probably 2 ounces rather than increased to 4 ounces or above.

23. The lowering of natural gas distributing pressure to approximately 2 ounces would produce more efficient and satisfactory operating conditions for the consumer, would greatly curtail the leakage on the consumer's premises, which is paid for by the consumer, and would also substantially lower the leakage in the gas company's distributing plant.

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WHAT IS CONSERVATION?

TRUE conservation is not hoarding, but the wise use of natural resources, and it implies not merely the preserving in unimpaired efficiency, but also a wise and equitable exhaustion with a maximum efficiency and a minimum waste. The heart of the natural-gas conservation problem is the conflict between the present and the future. The individual landowner is interested primarily only in immediate present personal returns. That is, he is thoughtless and indifferent with respect to the future. The public—at least the 2,000,000 domestic natural-gas consumers and the 10,000,000 people dependent on natural gas for their cooking, heating, and lighting purposes—are interested in conserving the supply and bringing about a slow, wise, and economical exhaustion, so as to insure continuity of service for the future.

Conservation, therefore, demands intensive rather than extensive use, takes cognizance of equitable distribution, aims to bring about social justice, and means the greatest good to the greatest number—and that for the longest time.[1]

[1] Phrascology suggested by Prof. C. R. Van Hise's The Conservation of Natural Resources in the United States, and Prof. Richard T. Ely's Conservation and Economical Theory, Transactions American Institute Mining Engineers, vol. 54, p. 458.

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